R E P O R T R E S U M E S

ED 018 967 EF 001 583

COMPUTER MODELING IN CAMPUS DESIGN. CASE STUDY AT DUKE UNIVERSITY. FINAL PAPER.

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PUB DATE DEC 67

EDRS PRICE MF-$0.25 HC-$0.56 12P.

DESCRIPTORS- *CAMPUS PLANNING, *COMPUTER PROGRAMS, *CAMPUTERS, *CYBERNETICS, COLLEGE PLANNING, DATA PROCESSING, DESIGN, ELECTRONIC DATA PROCESSING, INFORMATION PROCESSING, MASTER PLANS, PLANNING, PROGRAMING, SPATIAL RELATIONSHIP, SPACE UTILIZATION,

IN A PILOT STUDY CONDUCTED TO PROVIDE BETTER INFORMATION FOR CAMPUS PLANNING, COMPUTER PROGRAMS WERE DEVELOPED TO ANALYZE DATA COLLECTED FROM STUDENT DIARIES. AREAS OF CONCERN INCLUDED--(1) TIME SPENT IN A SPECIFIC ACTIVITY, (2) TRAFFIC ACTIVITIES AND RELATED VARIABLES (COSTS, ETC.), AND (5) PROJECTION OF FUTURE CAMPUS ACTIVITY-SPACE RELATIONSHIPS AND THE RESULTING IMPLICATIONS OF VARIOUS ACTIONS PROPOSED BY THE PLANNERS. THE GOAL WAS TO MAXIMIZE THE BENEFITS FOR THE LEAST COST. THIS PAPER IS THE FINAL COPY OF A PAPER PRESENTED AT THE AIA ARCHITECT-RESEARCHERS' CONFERENCE, GATLINBURG, TENNESSEE, OCTOBER 24-25, 1967. (JT)

ED018967

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Presented at AIA Architect-Researchers' Conference

Gatlinburg, Tennessee

24-26 October 1967

Final Paper
8 December 1967

COMPUTER MODELING IN CAMPUS DESIGN

Case Study at Duke University

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EF 001583

The impressive growth of educational enterprises across the country clearly demands that every available tool must be employed to create orderly and logical expansion of college and university campuses. Recognizing that the computer can be a powerful tool in planning and that few colleges and universities use it for this purpose, Educational Facilities Laboratories and Duke University are sponsoring a study to develop and demonstrate applications of the computer for use by campus planners. The term planner includes members of a team -- administrators, consultants, architects -- who may be involved in determining the development of campus physical facilities. Such a team was organized for this study and has included Caudill Rowlett Scott, Architects Engineers and Planners, and Hewes, Holz and Willard, Educational Data Processing Consultants, in addition to administrators at Duke. The applications discussed here were developed under this grant during 1967. They are meant to be demonstrative, not definitive. We are seeking neither normative data nor universally applicable answers; we are probing.

OBJECTIVES

The goal for the study is to provide more timely and more nearly complete information upon which to base academic, financial, and architectural planning decisions. Two objectives emerge in working towards this goal.

1. To provide techniques which demonstrate implications of alternate solutions before choosing one plan of action.

2. To gain a better understanding of planning facilities for non-scheduled activities such as study, research, and recreation. These activities constitute the largest and most difficult design elements of the campus planning problem.

THE PROCESS

Planning must be a dynamic process; it requires constant and continuing attention. It must be a rational process, one by which the most appropriate courses of action are determined to derive maximum use of available resources to achieve stated goals. In an effort to understand this process, planners must define the flow of information and the operations involved. One definition follows these steps:

1. Define goals
2. Find facts
3. Analyze data
4. Formalize concepts
5. Project needs
6. State the problem
7. Synthesize alternate plans
8. Evaluate plans
9. Select plan
10. Implement plan

If the purpose of planning is to achieve specific goals, the first step of any planning effort is to define goals and objectives. Goals are like horizon lines: they are always distant and receding;

but goals must be recognized and defined because they provide the large framework for all planning. Objectives are also important as significant intermediate effects which can be realized and evaluated. A campus operates with people, structures, land, and money. Basic information about these resources must be collected and analyzed to provide information for the planner. Policies are the specific rules which govern the employment of institutional resources and must be examined for conflicts and placed in a hierarchy of significance.

Planning concepts are form-giving ideas which result from the interpretation of institutional goals, policies, and unique characteristics of resources. These concepts provide the basis for making projections of activity-space allocation and location requirements. Planning programming, then, involves the steps of goals definition, collection and analysis of data about resources, the definition of concepts, and the projection of resource requirements. Programming culminates in statements of needs (extent of activities, space requirements, funds required, etc.) and of the problems which stand in the way of satisfying those needs. The continued role of planning is to produce solutions which will minimize the problems and most nearly satisfy the needs.

The design aspect of the planning process consists of 1) describing alternate courses of action which are possible within the limits of the problem and which would appear to satisfy the needs, and 2) evaluating each of the actions in terms of realizing objectives. Evaluation of plans in relation to costs and benefits enables the

planner to select the best course of action. Effective management requires that the actions necessary to carry out the plan evolve from the same base which established that plan.

To construct a model is to represent abstractly part of the real world for purposes of study. The planner can model a campus with cardboard, wood and paint, pencil and paper, or mathematically. We have developed several computer programs which demonstrate that a campus can be described, in part, numerically. Hence, computers can be employed to model portions of the campus during several stages of the planning process.

DATA COLLECTION AND ANALYSIS

Student activities are among the operations which characterize any college or university. These activities may be categorized in any one of several ways; useful broad classifications are academic/non-academic and scheduled/non-scheduled. Scheduling of many activities results from the simple necessity that students and professors need to know when and where to find each other. Computer applications in scheduling, and the resulting uses of space, directly aid the planning of facilities for these functions. For example, utilization studies have been developed at colleges and universities which show the use of classrooms and labs for regularly scheduled activities. These computer studies make use of space inventory and class record files to display the use of each room, aggregated use of room types by capacity, spaces used by each instructional department, etc. This information may be plotted to study the variations in use of space across the campus.

Knowing the use of each space in the past, the administrator can better forecast future use. Such information is essential to projecting future space requirements. In general, these programs deal with managing scheduled activities. Considering the 168 hours of a week, we speculated that about 10 to 15 per cent of a student's time is spent in scheduled class work. The space alloted to these activities on most campuses is a correspondingly small percentage of the total space. If sleeping consumes 25 to 30 per cent of the week, more than one-half of a student's time at the institution remains unscheduled in activities such as study, research, and recreation.

While no institution should control every aspect of student life, administrators must face certain questions in response to stated goals: Where should students study? What should our student union be? How can the learning resource centers be made more effective? In short, the planning team needs to know what facilities should be provided for non-scheduled activities at the particular campus being designed.

One attempt to collect data from which partial answers may be sought is the use of student diaries. This technique was pursued as a pilot study in March of this year at Duke University. One hundred undergraduate students were selected at random and asked to help in the collection of data concerning the student use of facilities. Each student maintained a diary of his activities for seven consecutive days, 24 hours a day, and recorded the location, beginning time and some description of

the activity itself. The diary was administered largely by students acting as monitors; the response was enthusiastic, and we feel that the data is reasonably reliable in indicating gross patterns. The diary entries were converted to machine readable records and programs written to analyze them.

In general, two types of computer programs were developed for analyzing the diaries: graphs using the computer printer and overlays to the campus map using a mechanical plotter. These programs display information important to two aspects of the planning problem: allocation and location of institutional resources.

For purposes of initial summaries, the activities found in the diaries were aggregated into six categories: Lecture, Laboratory, Study,, Recreation, Sleep, and Miscellaneous. A tally was made using all the diary entries to show total manhours spent in each activity by hour of the day for each of seven days. The program could be used to produce a similar graph for any activity in the diary. Separate tallies could be generated for specific groups such as senior engineering students, graduate students, or all women students. Analysis of these activities indicates type and quantity of activities produced by a student body of given characteristics. The planner must then anticipate changes in characteristics and mix of the students, and estimate changes in activities. Type and quantity of these functions may then provide a better basis for allocating space to non-scheduled activities.

Another use of the student diaries was to generate an origin and

destination study of student traffic flow. The structure of the data reflects events sequentially by type of activity, location, and time of day. Thus, each student can be followed through his travels for the full week. Duke University operates with a campus split between the Gothic West Campus and the East Campus, formerly the women's college. The travel between the two campuses and to off-campus facilities is of concern to the planners in developing facilities on the two campuses, and to the administration in scheduling class meetings. A plot of the traffic for the week was made as an overlay to the campus map by summing the trips found in the student diaries. The study reflects the total traffic volumes during the week, not just peak loads. The plot consists of the various facilities being linked by rectangular bands representing traffic; the width of the band is proportional to the volume of traffic between the two facilities. Current patterns can be studied in relationship to the existing set of facilities, and the location of future facilities can be studied in light of these patterns. Future patterns can be estimated because the current pattern is related to specific activities and types of students. Changes in the characteristics of the students and of their activities could be suggested, new "diaries" simulated, and the probable traffic patterns plotted.

The use of various types of spaces for non-scheduled activities must be considered. Another overlay to the campus map was produced showing circles encompassing the various facilities. The area of each circle is proportional to the amount of time spent in that facility. Similar plots could be produced for any single activity

or specific grouping of activities. For example, an overlay could be produced to show where students study and, in turn, could be related to the type of space used for studying. The planner could have separate displays for the time spent in classrooms, dormitories, union, etc. The display also could be limited by time (e.g., the hours not normally used for scheduling classes).

These techniques are primarily concerned with the collection and analysis of data to help suggest allocation and location of activities and facilities. There still remains the task of applying the information derived from analysis to find the best combinations of facilities in their proper locations.

EVALUATION

The planner is faced with assimilating large quantities of data with interrelationships which are often complex. Because any action which he proposes may have many ramifications, it is often desirable to study several alternative plans before selecting one course of action. Our study has developed the framework for a computer program to evaluate proposed plans. To be useful to the campus planner, evaluation must provide information about the benefits, costs, and phases implied in the proposed actions. It is desirable to simulate the execution of these actions and to observe the results before choosing one plan over another. The closer the simulation can be made to represent the action of the real world, the more confidence the planner can place in the evaluation.

Basic to planning a campus is the recognition that the college or university is a system, that is, a set of functionally related

components which work together towards some common objective. The components for the campus, as seen by the campus planner, might be activities, space, time, and money. Each component can be characterized by various attributes. There are specific quantities of activities; spaces can be measured and catalogued, money is constrained by rules for its use, etc. More importantly, relationships must be defined and studied. These relationships may be expressed in terms of activity growth patterns, space assignments and utilization, interzone site distances, site densities, etc.

Information about these elements and their interrelationships is provided as basic input to the computer evaluation program. For each budget cycle, the funds available for construction are given. The campus is zoned geographically and space is assigned to activities by zone. Distances between centers of activity in these zones can be expressed in feet or in travel time.

Affinity is the attraction or non-attraction between one activity and any other activity. At this point, our study of affinities has dealt primarily with the results of an academic registration crossover study. It produces the number of student clock hours generated as an instructional load on one department by the majors in each of the other departments. The values reflect, in one sense, the academic ties between one academic activity to each of the others. Further investigations to define affinities should involve a study of interdepartmental research, joint use of various space types, and perhaps the departmental or administrative desires for one activity to be associated with other activities.

Control devices provide the planner with an opportunity to define the most obvious constraints on assigning activities to zones. These constraints may result from topography limitations or from the appropriateness of assigning activities to specific areas of the campus. Other information about the elements of the campus is provided, such as the growth ratios over time, the range of allowable utilization, and areas of the geographic zones. Once the basic configuration of the campus has been described, conditions of the campus in future time periods are simulated. The levels for each activity at the given time are calculated. These activities may produce critical pressures on the resources of space, land or money. In the context of this study, criticality is the expression of an excess or deficiency in some attribute of an activity or space relationship when compared to the limits established by the planner. Activities can be critical due to extremes of utilization, lack of space assignment, or condition of the space to which it is assigned. Campus zones may exceed allowable density and become critical; or there may be conflicts in space assignments and placement goals. The objective of the program is to provide the planner with a means of examining various courses of action to alleviate these pressures. The role of the computer is to display the status of the campus activity-space relationships and the resulting implications of taking various actions which the planner may propose. From information provided in the printout, the planner suggests actions to alleviate pressures. Actions available to the planner are to build, demolish, or reassign space. Assembling a set of these actions constitutes a project. Based on various parameters

of the project, the actions are executed as appropriate with the available resources. The characteristics of the campus components are altered as a result of the actions, and the simulation continues through succeeding cycles. A measure of effectiveness is calculated for each set of actions which constitutes a plan. The goal is to maximize the benefits for the least cost.

CONCLUSIONS AND CONTINUATION

The computer, as a planning tool, can be very helpful not only in organizing, storing, and retrieving data, but also in the design process of proposing and evaluating sets of actions. It is anticipated that this study will continue through the summer of 1968, but it will only hint at many of the applications possible. Efforts will be aimed towards 1) better definition of the planning process, 2) more complete space inventory files, 3) a larger scale collection effort on student activities and possibly faculty activities, 4) development of an activities/space use simulation model, and 5) further development of the evaluation program.

An interim report on this study, Computer Aided Campus Planning for Colleges and Universities, August 1967, is available through Educational Facilities Laboratories, 477 Madison Avenue, New York, New York 10022.